Analysis of Life Cycle Cost Concepts and their Implementation by the Naval Facilities Engineering Command

by
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and their Implementation by the
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LIST OF ACRONYMS

A/E - Architect and Engineering firms
APMM - Activity Planning and Management Model
BOS - Base Operating Support
BRAC - Base Realignment And Closure
BFR - Base Facility Requirement
CEC - Civil Engineer Corps
CMC - Commandant of the Marine Corps
CNO - Chief of Naval Operations
D/B - Design Build
DOD - Department of Defense
DODI - Department of Defense Instruction
DOE - Department of Energy
DOL - Department of Labor
EFA - Engineering Field Activity
EFD - Engineering Field Division
FAR - Federal Acquisition Regulations
GAO - General Accounting Office
GSA - General Services Administration
HQ - Headquarters
JCS - Joint Chiefs of Staff
LCC - Life Cycle Cost
MILCON - Military Construction
MIL HDBK - Military Handbook
OMB - Office of Management and Budget
OPNAV INST - Chief of Naval Operation Instruction
NAVFAC - Naval Facilities Engineering Command, also NAVFACENGCOM
NCF - Naval Construction Force
PWC - Public Works Center
PWD - Public Works Department
SECAIRFORCE - Secretary of the Air Force
SECARMY - Secretary of the Army
SECNAV - Secretary of the Navy
SOUTHDIV - Southern Division of NAVFAC
SOUTHNAVFACENGCOM INST - Southern Division Naval Facility Engineering Command Instruction

STATEMENT OF PURPOSE

The Navy, like many other federal organizations, is being faced with a decreasing budget. One of the Navy's biggest problems is that owning and operating their shore infrastructure is consuming too much of its limited resources. One way to reduce the cost of owning and operating the shore infrastructure is to plan and design facilities with lower life cycle costs i.e., facilities with components that last longer, cost less to operate, and cost less to maintain. Naval Facilities Engineering Command (NAVFAC), as with all federal agencies, has been directed to perform economic analysis based on Life Cycle Cost (LCC) concepts on all Navy facility projects. However, in a recent study, NAVFAC found that a majority of their facility project areas were not using LCC concepts when conducting economic analysis.

This paper will: 1) provide a brief introduction to life cycle cost concepts and economic analysis; 2) introduce NAVFAC and its role in the facility planning process; 3) summarize current federal policies regarding facility planning and LCC concepts; 4) summarize NAVFAC's report concerning the status of LCC in the planning process; 5) analyze and make recommendations to two main issues hindering NAVFAC use of LCC.

Chapter 1.0 Introduction

The Navy, like many other federal agencies, has been faced with major budget cuts and downsizing. These budget cuts have reduced the Navy's ability to adequately fund both infrastructure and capital expenditures (ships, planes, submarines, and weapons). Since the Navy's core mission is to provide these capital capabilities, it must reduce the amount of resources typically dedicated to the infrastructure. In summary, in order for the Navy to continue operating at its current budget requirements, the Navy must find ways to reduce infrastructure costs.

One way to reduce infrastructure costs is through the use of life cycle cost concepts. Life cycle costs concepts take into account all costs related to construction, operation, maintenance, and disposal over the life of the facility. When faced with a new facility requirement or debating whether a facility should be upgraded, decision-makers are faced with a number of choices. Economic analyses based on life cycle cost have been developed to assist decision-makers in selecting the best economic alternative.

The Naval Facility Engineering Command (NAVFAC) is responsible for providing technical support for facilities infrastructure to the Navy and other federal agencies. One of NAVFAC's main functions is to provide support to the facility planning process. Facility planning is integral to the overall growth and development of a given installation. A major focus of facility planning is conducting economic analysis based on life cycle costs processes.

The Department of Defense (DOD) provides guidance to the Department of the Navy and NAVFAC through policies and instructions. In regards to facilities, policies have been issued on facilities planning, project development, and economic analysis.

Based on customer concerns with high infrastructure costs, NAVFAC examined its implementation of LCC concepts. The report titled "Mandating Life Cycle Costs Consideration in Projects" is the result of NAVFAC's examination. The report identified major issues hindering the use of LCC concepts and developed recommendations to assist the implementation of LCC concepts.

Two key issues from the NAVFAC report were analyzed and recommendation provided. The two issues are: 1) lack of accurate costs data and 2) lack of ways to help field offices incorporate life cycle costs concepts into facility designs.

It has been concluded that life cycle cost concepts are one means to achieve the Navy's goal of lowering infrastructure costs. Recommendations will be presented to facilitate the implementation of life cycle cost concepts in the facilities planning process.

CHAPTER 2.0 LIFE CYCLE COSTS CONCEPTS AND ECONOMIC ANALYSIS

2.1 Life Cycle Costs (LCC) and their use in Economic Analysis

The true cost of any project that a facility owner executes includes more than just its initial costs. Projects have a host of costs associated with their acquisition, use, and ultimate disposal. These costs include: land, design, construction, operations, maintenance, and salvage value or disposal costs. Thus, the life-cycle cost of a project may be defined as the total cost that the owner incurs, from the time the facility is funded until the time the facility is disposed of.

Economic analyses based on life cycle cost concepts are used to evaluate competing alternatives. In conducting an economic analysis, all life cycle costs associated with each alternative are determined and expressed in equivalent dollars. Throughout the execution of the project (planning, designing, and construction), economic analysis should be at the core of any decision making process. Selecting alternatives based on the lowest initial expense often results in costing the owner more money over the life of the project, as shown in the following graph (Figure 2.1). The two columns on the left side of the graph represent the initial costs of Alternative 1 and Alternative 2 for an administration building. As shown in the graph, Alternative 1 has the lowest initial cost. However, when comparing the total life cycle costs (two left columns in the graph) for the two administration building alternatives, Alternative 2 has the lowest total life cycle cost.

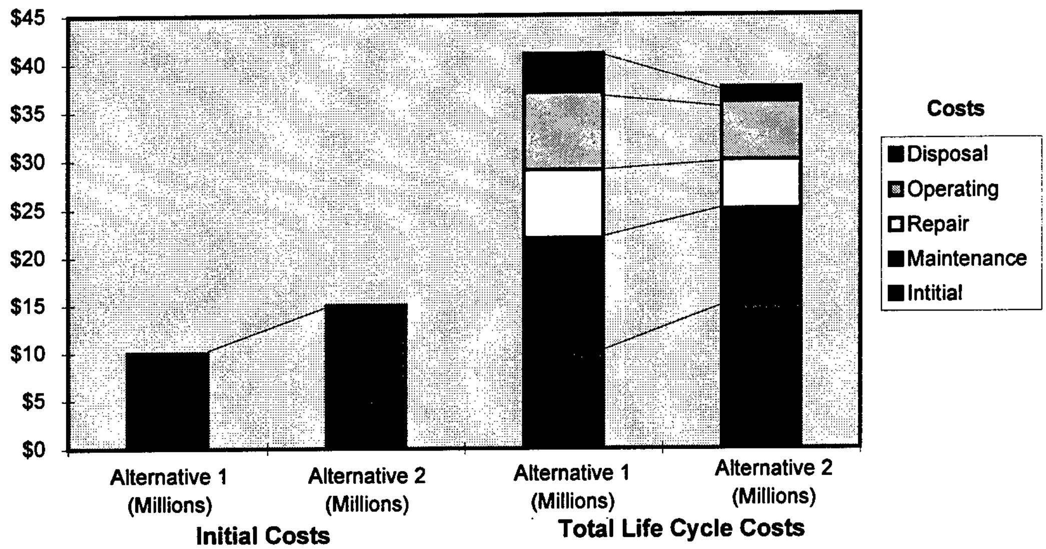

Figure 2.1. Comparison of Initial Costs to Total Life Cycle Costs [Gess, 1994]

2.2 Types of Economic Analysis

Economic analysis can be classified in several ways according to (1) their purpose and (2) feasible alternatives. Economic analysis based on purpose is either primary economic analysis, also referred to as Type I, or secondary economic analysis, also referred to as Type II. Economic analysis based on feasible alternatives are either investment or design economic analysis.

Primary economic analyses are used to reduce the cost of an existing condition. For example, an HVAC system has been installed at a facility for 5 years. A new HVAC system has been developed which is considered to be more efficient. The owner may

want to consider replacing the existing system with the new system in order to save long term money or achieve other economic benefits.

Secondary economic analyses are used to determine the most effective way of satisfying a new functional requirement. For example, a company needs more office space. The owner should consider which is more economical: to build a facility, lease an existing facility, or renovate an existing facility [Kirk&Dell'Isola,1995].

Investment economic analyses are always performed and are done in the planning stage of the facility process. An investment economic analysis is undertaken to determine which of several strategic alternatives of action is most economical in meeting a specified project objective. The alternatives considered could be to "do nothing", renovate an existing facility, lease a facility, or construct a new facility

Design economic analyses are used once the best investment alternative has been selected. Design economic analyses are completed in the conceptual design stage of a project to determine the most economic design to use. Because an investment decision has been made, the do-nothing alternative is not an option in the design stage. The alternatives considered could be to construct a one story building versus a two story building (given the same square footage) or to construct the building using steel versus concrete. A summary of the different types of economic analyses are shown in Figure 2.2: [Kirk & Dell'Isola, 1995]

Feasible Alternatives	Objective	Principal Purpose: Type I Primary (Save Money or other economic benefit)	Principal Purpose: Type II Secondary (Satisfy Functional Requirement)
Investment (Feasibility Phase)	Determine:(1) Whether an investment is justified, and if so, (2) the most Economic solution	Replace existing high cost facility. Install energy saving devices.	Do nothing, renovate, lease or construct new facility
Design (Design Phase)	Seek the most economic design solution which satisfies the required function.	Not applicable	Single story vs. multi-story Type of Mechanical Syste

Figure2.2. Types of Economic Analysis [Kirk&Dell'Isola,1995]

No matter which type of economic analysis you are conducting (primary, secondary, investment, or design), the general process of economic analysis is basically the same.

2.3 Economic Analysis Process using Life Cycle Cost Concepts

Economic analysis is a process used to evaluate various alternatives. The facility owner uses the findings from the analysis and other factors to make a sound economic decision on which is the best alternative. When conducting the economic analysis it is important that the decision be unbiased and that the alternatives be judged fairly. To ensure this is accomplished, each of the following steps must be completed in its entirety and the degree of effort be consistent between alternatives:

(1) Define the project objective

(2) Generate alternatives

(3) Formulate assumptions and constraints

(4) Determine relevant benefits and costs

(5) Select the best alternative

It also important that each step be documented to include: sources of information, facts used, assumptions and constraints made, and justification for decision. The steps identify work for all types of economic analysis.

2.3.1 Define the Project's Objective

The first and most important step in the economic analysis process is defining the project's objective. The project objective should satisfy the requirements set forth by the owner and should incorporate an easily measurable standard of execution. For example: provide 10,000 square feet of office space. Any implicit standards that the owner wants the project to meet must also be included in the project criteria. For example, the facility must meet all federal energy requirements and specific quality standards. The objective statement should be unbiased so as not to sway the decision in selecting the best alternative. For example, provide 10,000 sq. ft. of office space versus construct 10,000 sq. ft. of office space. The second statement is in the form of a solution and may sway the decision maker towards construction of a new facility.

2.3.2 Generate Alternatives.

Once the project objective has been developed, the next step in the economic analysis process is to identify the alternatives. Alternatives are selected based on whether they meet the minimum functional and technical requirements stated in the project's objective. Since the purpose of economic analysis is to assist the owner in making an economically sound decision, it is important that all feasible alternatives are identified.

2.3.3. Formulate Assumptions and Constraints

Economic analysis also deals with future benefits and costs. With future benefits and costs, there is an element of uncertainty. Assumptions must be made and constraints must be considered. Assumptions should be used to bridge gaps that are left from the lack of factual information. The assumptions may include, but are not limited to, the following items: discount rate, functional life of the facility, and future functional requirements of the facility. Whenever possible assumptions should be based on historical or technical factual information.

Constraints are another restriction that must be considered. Constraints are external factors relevant to the environment which may limit the number of alternatives. Constraints can be categorized as the following:

1) Physical, the fixed amount of space.
2) Time-related, the fixed deadline.
3) Financial, the limited budget.

4) Institutional, the organizational policy.

Frequently, assumptions and constraints must be developed before you can generate alternatives. Care must be taken when developing assumptions and constraints. If the assumptions and constraints are too restrictive, they may eliminate feasible alternatives.

2.3.4 Determine Relevant Benefits and Costs

The most difficult part of economic analysis process is determining all the relevant benefits and costs associated with the life of each of the alternatives. The steps to determine benefits and costs are:

(1) determine length of study period

(2) identify and quantify benefits and costs

(3) bring all benefits and costs to an equivalent dollar base

(4) document all sources and calculation.

It is important to be consistent between the different alternatives and to obtain only the relevant benefit and cost estimates.

1) Determine Length of Study Period

A time period (referred to as the study period) must be established over which the benefits and cost will be identified for each alternative. The length of the study period should be based on the owner's investment interest and should take into account expected lives of different alternatives. All alternatives' benefits and costs are determined over the same study period.

2) Identify and Quantify Benefits and Costs

The main goal of a public sector project is to fulfill the project's objective. Any benefits exceeding the minimum requirements are usually not sought. However, any benefit provided by an alternative beyond the basic requirements should be considered. Benefits are of two types: monetary and non-monetary. Monetary benefits include: direct cost savings, productivity increases, and other quantifiable outputs. Non-monetary benefits can include: aesthetics, expansion potential, flexibility, safety, morale, and others. Monetary benefits are treated as negative costs, and non-monetary benefits beyond the minimum requirement are documented, but normally not considered unless the competing alternatives are otherwise essentially equal.

Future costs although often difficult to estimate, are easier to quantify than benefits. The two general categories are one-time costs and recurring costs. The distinction is necessary because the calculation to bring a one-time cost to present worth is different from the calculation to bring a recurring cost to the present worth. One-time cost can be further broken down into the following elements:

1) Initial costs (facility design, real estate acquisition, facility construction, etc.)
2) Alteration and replacement costs (facility rehabilitation or modification, one-time equipment replacement, etc.)
3) Residual or terminal costs(facility salvage value or facility demolition).

Recurring costs can be broken down into four categories:

1) Maintenance costs (regular custodian care, and repair, annual maintenance contracts).

2) Operation costs (energy costs, salaries of the operation personnel).

3) Financing costs (costs of debts).

4) Associated costs (other identifiable costs not covered by the other elements to include insurance, security, etc.).

3) Bring all benefits and costs to an equivalent dollar base

Once the costs and benefits have been estimated for the life of each alternative, it is important to use equivalent dollars when performing the economic analysis. Costs identified for each alternative are grouped by year over the number of years of the study. All costs are then converted to today's dollars by using present worth techniques (refer to Kirk & Dell'Isola Chapter 2). In the present worth technique, discounting is done because a cost incurred in the fifth year of a facility life is not the same as one incurred in the first year. Once all the costs and benefits (benefits are treated as negative costs) have been discounted to equivalent terms, they are totaled for each alternative to determine each alternatives' life cycle costs. At this point in the process, it may be necessary to do a sensitivity analysis on certain assumptions or cost elements. If a reasonable modification in any of the assumptions and cost elements would change the conclusion of the analysis, the probability of such an occurrence must be weighted. If two or more events have roughly the same probability of occurrence, the option will normally be based principally on costs [Kirk&Dell'Isola,1995].

4) Document all sources and calculation

The validity of the economic analysis is dependent on the quality of the input data (which is basically the benefit and cost data). Therefore , all benefit and costs data should be well documented. Documentation should include; 1) sources of information, 2) calculations used to produce input information, 3) assumptions made to bridge caps left by lack of factual information, and 4) all sensitivity analyses. Once the life cycle benefits and costs have been determined the next step is to select the best alternative.

2.3.5 Select the Best Alternative

To select the best alternative, the owner has to decide what type of economic approach meets their need. The owner has two choices: investment economic analysis or design economic analysis. The decision for investment analysis is normally based on one of the following economic approaches: payback period, return on investment, or savings to investment ratio. For design analysis, one of the following approaches may be taken: present worth or annualized life cycle costs. Before the final decision is made, the decision maker should take into account economic analysis and all monetary and non-monetary factors. See Appendix A for a description and/or example of the five approaches [Kirk&Dell'Isola,1995].

Chapter 3.0 Naval Facility Engineering Command and its Role in the Facility Process

3.1 Introduction to NAVFAC.

The Naval Facility Engineering Command, or more commonly referred to as NAVFAC, is responsible for providing technical support to the Navy, Marine Corps, Department of Defense (DOD) and other federal agencies in the following areas: shore facilities, real property, utilities, fixed ocean systems and structures, transportation equipment, environmental and energy programs. NAVFAC is also responsible for managing the Navy's Base Realignment and Closure (BRAC) Program and the Naval Construction Forces (Seabees). The technical support provided by NAVFAC might include any or all of the following services: planning, design, construction, management, operation, maintenance, and disposal. [NAVFAC HOMEPAGE]

As mentioned above, NAVFAC provides facility management services to the Navy and Marine Corps System Commands (SYSCOMs), activities and claimants. The services provided by NAVFAC are accomplished through the headquarters office in Washington, DC and a number of subordinate commands. Engineering support and services are provided to hundreds of activities of naval shore establishments through 10 Engineering Field Division (EFD's) and Engineering Field Activities (EFA's) located across the United States and Europe. Public Works Centers, (PWC's) and Public Work Departments, (PWD's) provide naval establishments with shore facilities repair, maintenance, and utilities support. Naval Construction Forces, (NCF or SEABEES)

conduct contingency operations throughout the world. Finally, there are a number of miscellaneous departments that deal with very specific areas such as energy and environmental issues. NAVFAC's 23,376 employees, which includes active duty Civil Engineer Corps officers, Seabees, and civilians, handle an annual volume of business that exceeds $7 billion [NAVFAC HOMEPAGE]. See Figure 3.1, to understand how NAVFAC's organization fits into the organization of the Federal Government.

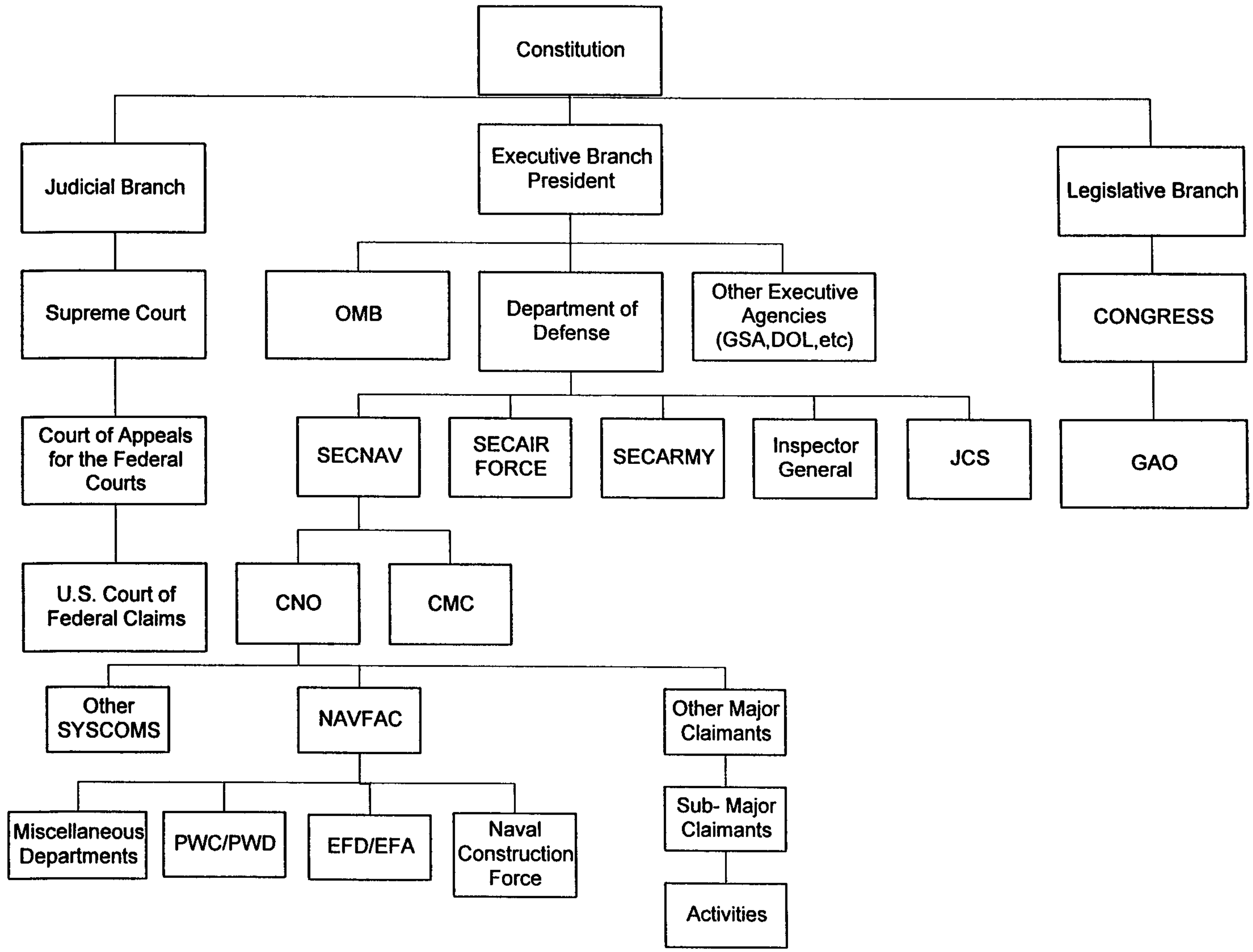

Figure 3.1 Organization of the United States Federal Government. (NFCTC, Contract Law)

3.2 NAVFAC's Role in the Facility Process

As the Navy's facilities expert, NAVFAC plays the major role in the facilities planning process by providing technical services and guidance, to their DOD and Navy customers. The following is a general overview of the services NAVFAC provides in the facility planning process:

When a facility requirement is identified by a customer, NAVFAC field offices assist the customer in defining the Basic Facility Requirements, (BFR). Once the BFR is complete, the PWD/PWC or EFD/EFA assists the customer in determining and developing all the alternatives available that can satisfy the BFR. The alternatives may include: do nothing, use an existing facility, renovate an existing facility, lease off-base, or construct a new facility. When all the options are identified, PWC/PWD or EFD/EFA assists the customer in conducting an economic analysis, based on life cycle cost concepts of all the alternatives. Based on the customer's mission, life cycle cost analysis, health and safety issues, environmental compliance, quality of life issues, or some combination of the above, the customer selects the best alternative [OPNAV INST11010.20F Facilities Projects Manual].

Once the alternative is selected, the PWC/PWD or EFD/EFA assists the customer in organizing the documentation for the project submission. NAVFAC also helps customers prioritize their facility projects. For Military Construction (MILCON) Projects, which are defined as new construction over $500,000, NAVFAC assists in the prioritization of the MILCON Project List. The MILCON budget is developed and

submitted to Navy's Budget office and eventually will be included in the DOD budget submitted for approval to Congress.

Once a project is approved and funded, the customer may proceed with the execution of the project. Any one of the following agencies can execute a project: Activity, Claimant, EFD/EFA, local PWC/PWD, or a special program sponsor. Normally the EFD/EFA or PWC/PWD is the execution agent. Project execution includes designing, constructing, and commissioning the project. There are a number of alternatives that can be used to complete the various phases of project execution. Design services can be completed in-house by an EFD/EFA or PWC/PWD, contracted to an A/E, or to a design build firm. Construction and commissioning services can be completed by using PWC/PWD in-house shop forces , a construction contract, tasking the Base Operating Support Contracts (BOS), Naval Construction Forces, or a combination of any of the above.

EFD/EFA's and PWC/PWD's are normally responsible for completing and reviewing the economic analysis during the planning stage of the facility process. They are also responsible for the design stage of the facilities process, which includes: developing the facility design criteria, reviewing designs submittals, and approving the final design. They would be the organizations most impacted by the use of life cycle cost concepts.

Chapter 4.0 Summary of Current Federal Policies and Guidelines associated with Planning, Energy, and Economic Analysis.

4.1. Sources of Guidance

NAVFAC receives guidance and directions from the following agencies: Office of the President of the United States, Secretary of Defense, Secretary of the Navy, and Chief of Naval Operations. Each agency mentioned above has issued an instruction which provides guidance to planning facilities, energy conservation, and/or conducting economic analysis using life cycle cost concepts. Guidance for facility planning and the requirement to perform economic analysis is provided in:

1. Department of Defense's Military Handbook 1190 Facility Planning and Design Guide (MIL HDBK1190);
2. NAVFAC 11010.44E (NAVFACINST 11010.44E), Shore Facilities Planning Manual
3. Chief of Naval Operations, Instruction OPNAV Instruction 11010.20F Facilities Project Manual.

Guidance for energy management in federal buildings is covered by many policies. For the purpose of this paper only one policy will be presented: Executive Order 12759, Federal Energy Management.

Economic analysis guidance starts at the very top with the President of the United States and works it way down through NAVFAC. The following instructions have been issued in regards to economic analysis:

1. Office of Management and Budget's Circular A-94 (OMB A-94);
2. DOD Instruction 7041.3 "Economic Analysis for Decisionmaking" (11/07/95)
3. NAVFAC P442 "Economic Analysis Handbook".

4.2 Facility Planning Guidance

The Military Handbook (MIL HDBK) 1190 Facility Planning and Design Guide is a design manual published by DOD which applies to all DOD components, except health care facilities. The manual is a guide to design criteria for different types of facilities. It also provides guidelines for using different construction alternatives to meet the mission requirements such as: new construction, repair, or renovation of existing permanent and temporary facilities. As per MIL HDBK 1190, design decisions for all types of facility projects should be made based on life cycle cost concepts.

The life cycle cost studies should provide an economic cost analysis based on initial cost; operating and maintenance cost; and impact of the primary function of the facility over its life time. For all major projects (referred to as large administrative buildings, command centers, etc.), economic studies should be conducted in the design phase of the project. The studies should include functionality, flexibility, and location considerations. Alternatives should be compared based on life cycle cost concepts to

determine the optimum building design. The MIL HDBK also references energy conservation policies regarding the use of life cycle cost analysis in design decision of new construction and major renovation projects.

The two primary sources for guidance for Navy shore facilities is, the Shore Facilities Planning Manual, NAVFAC Instruction 11010.44E, and the Facilities Project Manual, OPNAV Instruction 11010.20F. There are other instructions that provide information but these two instructions provide the main guidance. NAVFAC INST 11010.44E provides planning guidance to new military construction (MILCON) projects over a value of $500,000. The instruction provides a five step process to determine the facilities necessary to accomplish the assigned missions; ensure optimum utilization and maintenance of existing assets; and to plan for facility disposal and acquisition. The five steps are as follows:

(1) Facility Requirements

(2) Assets Evaluation

(3) Analysis, Concepts, and Proposals

(4) Implementation

(5) Quality Assurance

In step 3, Analysis, Concepts, and Proposals, of the process and throughout the instruction, guidance requires all projects to have an economic analysis performed, documented and submitted with the project package. The instruction also provides simple economic analysis procedures, which are based on life cycle cost concepts, and

also references NAVFAC P442, Economic Analysis, for a more detailed procedure for conducting economic analysis.

Facilities Project Manual, OPNAV 11010.20F provides planning guidance for all facilities projects, regardless of funding and approval authority. The instruction provides policy and guidance for preparation, submission, review, approval and reporting on facilities at Naval shore facilities. Within the project justification portion of the instruction there is a requirement that a project be justified based on "… mission, life cycle economics, health and safety, environmental, quality of life, or some combination of the above." [OPNAV INST 11010.20F]

According to the instruction, an economic analysis is required for facilities costing more than $500,000 and when more than 50% of the facility is replaced. An economic analysis is also required for all repair projects with an estimated cost greater than $2,000,000 and for all MILCON projects. Again, reference is made to NAVFAC P442 Economic Analysis, for guidelines and formats for preparing an economic analysis.

4.3 Energy Management Guidance

There are a number of policies issued dealing with energy related projects and energy requirements in federal buildings. For the purpose of this paper, only one of the primary energy policies will be presented. Executive Order 12759 "Federal Energy Management" requires that each agency develop and implement a plan to meet the 1995 energy goals of the National Energy Conversation Policy Act, and by the year 2000 energy consumption must be reduced by 20 % of the 1985 energy use levels, to the extent

that these measures minimize life cycle costs. The life cycle costs referred to are the total cost of owning, operating, and maintaining a building over its useful life and not just the life cycle cost related to energy consumption.

4.4 Economic Analysis Guidance

In regards to economic analysis, the requirement to perform Life Cycle Cost analysis starts from the highest level. The Office of Management and Budget (OMB), which is part of the Executive Office of the President of The United States, has issued Circular A-94 " Guidelines and Discount Rates for Benefit - Cost Analysis of Federal Programs" (10/29/92). The purpose of OMB A-94 is to provide the necessary methodology for conducting economic analysis and discount rates that are required to be used in economic analysis on federal projects. The economic analysis described is based on life cycle cost concepts.

The Department of Defense (DOD) has issued a publication of its own dealing with the use of economic analysis in the selection of projects, DOD Instruction 7041.3 "Economic Analysis for Decisionmaking" (11/07/95). DODI 7041.3 requires that an economic analysis, based on life cycle cost concepts, be submitted to the Under Secretary of Defense, Comptroller (USD C) to support budget line items. It also states that all feasible alternatives for meeting an objective must be considered and their life-cycle costs and benefits be evaluated.

NAVFAC policies echo the guidance provided by the aforementioned sources but with much greater detail and focused mainly on shore facilities. The NAVFAC P442 "Economic Analysis Handbook" is the primary document used by NAVFAC Programs

for conducting economic analysis. The economic analysis process presented in the handbook is based on the life cycle cost concept.

Chapter 5.0 The Status of Life Cycle Cost Concepts in NAVFAC's Facility Process

5.1 NAVFAC Improvement Plan

In December of 1995, Rear Admiral David J. Nash, CEC, USN Commander of NAVFAC, issued the NAVFAC Improvement Plan. The plan was developed by a board of key NAVFAC senior members. Its purpose was to improve the quality of services that NAVFAC provides to the Navy. In the NAVFAC Improvement Plan, the board addressed areas that concerned NAVFAC customers. One of the major problems identified was that "the owning and operating the shore infrastructure is consuming too much of the limited resources". [NAVFAC IMPROVEMENT PLAN]

One way to reduce the cost of owning and operating the shore infrastructure is to plan and design facilities whose components provide them with lower life cycle costs. That is, facilities which last longer and cost less to operate and maintain. The NAVFAC Improvement Plan tasked the NAVFAC's planning department with the following objective:

(1) Determine what existing guidance and policy has been issued directing the use of life cycle cost concepts.

(2) Determine if the various policies are adequate and consistent.

(3) Determine the level of implementation of life cycle cost concepts in NAVFAC Facilities Programs.

(4) Identify issues hindering the implementation of life cycle cost concepts.

(5) Make recommendations for actions to improve the implementation of life cycle cost concepts.

As a result of their efforts, the NAVFAC planning department developed the report "Mandating Life-Cycle Cost Consideration in Projects". A summary of the report is provided in Appendix B.

5.2 Findings from NAVFAC's "Mandating Life Cycle Cost Consideration" Report

The findings of NAVFAC's "Mandating Life Cycle Cost Considerations" Report are based on Federal, Navy and NAVFAC policies (the primary policies were presented in Chapter 4.0 of this report) and interviews with NAVFAC headquarters and field office personnel. As seen in NAVFAC's report and supported in Chapter 4.0, there is adequate guidance supporting life cycle cost concepts. The guidance is generally consistent between the various policies. However, the current programming, design, and construction practices are often inconsistent with life cycle cost concepts and policies. One of the primary reasons for the inconsistency is that Naval facility projects often have very tight budgets. This forces personnel to focus on alternatives with the lowest initial cost [Emmons 1997]. In addition, the report identified 18 other issues that hinder the implementation of life cycle costs concepts. They are:

1. Lack of specific guidance from the Office of Secretary of Defense and Navy Comptroller.
2. NAVFAC's customers do not understand the life cycle cost concept.

3. There are no recognized standards for assessing certain material and product life cycle costs.
4. Lack of accurate cost data in some areas
5. Preliminary estimates of facility costs are based on unit costs (For example, 1000sq ft of office space costs $100/sq.ft (unit cost), so the office space should cost $100,000). The current guidance for unit cost is set too low, which causes the facility's preliminary estimate to below. The preliminary estimate is used to establish project budget. Low facility project budgets limits the use of life cycle cost analysis.
6. Too much emphasis was placed on new construction instead of renovation and reuse of existing facilities.
7. Hesitancy to use new types of materials
8. Limited use of recycled materials due lack of testing data, industry standards, and lack of knowledge of their costs and uses
9. Limited proof that life cycle cost concepts are valid.
10. Program Budgets for facility projects are decreasing. But, rather than dropping projects, customers would rather cut the budget on each project. This limits or nullifies the use of life cycle cost approaches.
11. NAVFAC personnel are inexperienced in pursuing life cycle cost concepts through their architect and engineers, (A/Es).

12. Field Personnel lack training in the use of life cycle cost concepts when making design decisions.

13. Insufficient time allotted for designing projects restricts the use of life cycle cost concepts.

14. Unreliable data on existing facilities utilities consumption. Therefore project personnel are unable to determine if existing facilities are performing up to energy standards or do they need to be upgraded or replaced.

15. Insufficient data for projecting facility components' life expectancy.

16. Life cycle cost analysis tools are inadequate.

17. A/E's have no incentives to go above and beyond the basic design.

18. Not quantifying life cycle cost benefits in terms of increased productivity from properly designed and maintained workspaces.

These 18 issues hindering the implementation of life cycle cost concepts can be grouped into the following general categories. Lack of :

* Specific policy and concept knowledge to properly implement.
* Sufficient funding and planning time to properly implement.
* Accurate cost data.
* Ways to help field offices incorporate life cycle cost concept into the facility process.

The two issues: (1) Lack of accurate costs data and (2) lack of ways to help field offices incorporate life cycle costs concepts into facility process appear to be the most important and are discussed at length in chapter 6.

5.3 Recommendations from NAVFAC's "Mandating Life Cycle Cost Considerations" Report

In "Mandating Life-Cycle Cost Considerations in Projects", the Planning Department developed six recommendations to improve the implementation of life cycle cost concepts,

1. Establish a single point of contact within NAVFAC Headquarters Planning Department to handle all Life Cycle Cost Issues.
2. Review all Programming, Planning, and Design Practices in NAVFAC Headquarters and Field Offices to determine the various life cycle cost concepts employed.
3. Develop and issue one new Life Cycle Cost Policy that relates all other policy and guidance.
4. Establish a training program to educate all of NAVFAC on the life cycle cost concepts and analysis tools.
5. Review, evaluate, and if necessary revised Life Cycle Cost, Value Engineering, and Sustainable Design Policy to ensure they are consistent and current with today's practices (improved methods)
6. Establish metrics to monitor progress.

Chapter 6.0 ANALYSIS AND IMPLEMENTATION OF TWO KEY ISSUES IDENTIFIED IN THE NAVFAC REPORT

The shortcomings of the NAVFAC LCC program are due to the inability at the field level to properly implement the required processes. As shown in chapter 4, the general guidance provided by higher echelons is in place. Specific guidance to the field commands should be further developed. The NAVFAC report "Mandating Life Cycle Cost Consideration in Projects" listed 18 issues preventing proper utilization of life cycle cost concept, and five recommendations to assist in overcoming those issues. Two very important topics to analyze are:

(1) Lack of accurate cost data

(2) Lack of ways to help field offices incorporate the life cycle cost concept into the facility process.

Proper analysis of these topics will result in easier implementation at the field level.

6.1 Lack of accurate cost data.

Lack of current and accurate cost data has always been one of the main issues influencing the accuracy and validity of economic analysis. The life cycle cost analysis is a process that takes input data and provides output. The best and most complete processes can only produce output data that is as good as the input data. Therefore, if an accurate and complete evaluation is to be made the information going into the analysis must be accurate and complete.

Up to this point in time, NAVFAC has been unable to effectively track facilities recurring costs, especially maintenance costs. Most of the cost data comes from computer programs and published documents such as: Means Building Construction Cost Data, Means Facility M&R Cost Data, Dodge Guide to Public Works and Heavy Construction Costs (Annual), American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Energy Analyst Methods, Manufacturer Literature.

Cost data on facilities one-time costs (initial costs; alterations and replacement costs; and residual or terminal costs) are relatively accurate and up to date. The problem arises when it comes to acquiring data concerning recurring cost (maintenance and operating costs). The recurring costs data that is available is either outdated or very general. For example, the time it takes to collect, develop, print and publish cost data could take up to two years. Also, the information provided covers general purpose buildings types such as office space, hospital, and supermarkets. Military facilities cover a wide range of functions and can be very unique. Facilities range from hospitals, supermarkets, and power plants, to facilities such as weapon testing facilities, high tech communication facilities, ammunition storage facilities, and laboratories which are not all covered in cost data resources.

6.1.1 Implementation of the Activity Planning and Management Model, (APMM)

Several Navy bases are in the process of developing software programs that will track and maintain current maintenance and operation costs. Naval Surface Warfare Center, Crane, IN and Naval Air Test Center, Patuxent River, MD are two such facilities. They have developed software programs to track facilities information, such as type of components, function, floor plans, space utilization, and costs. The two installations are using a software program called Activity Planning and Management Model (APMM), also referred to as the electronic master plan. The basic objective of the APMM program is to provide activity managers, engineers, and administrators with rapid access to current, accurate and detailed real property information. To do this, APMM uses such software as MicroStation, Toolbook, AutoCad and ArcView CAD/GIS which are linked to a variety of database software to produce interactive graphic-based tools for land and facility analysis.[Onyx Group, 1996]

Both Crane and Patuxent River are in the process of expanding their APMM to track maintenance and operation costs per facility. Databases are established that will track and maintain the maintenance and operation costs based on facility identification (ID) number. For maintenance costs, when maintenance is completed on a facility, the maintenance personnel input the following information into a small portable computer: facility ID number, actual work completed, time taken to complete the work and any associated costs. At the end of the day, personnel download the information into the facility maintenance cost data base. Other maintenance costs such as custodian care are tracked as well. For the time being, energy costs are the only operations cost that will be

tracked. On most installations, there is one main meter which tracks electric and water usage for the entire installation. Crane and Patuxent are both beginning to install meters (permanent and temporary) on individual facilities. The metered information is then entered into the facility operation cost database.[Stuffle,1997]

The two databases will be integrated with the APMM program, so personnel can access APMM to find out all the costs associated with each facility. The data collected can be used for billing facility owners as well as providing accurate data for performing life cycle cost analysis for future facilities projects. Though realization of usable data will not be in the short term, the APMM program, and others like it, will provide accurate cost data vital to proper economic analysis and will continually update that data as facilities age.

The APMM is an excellent approach to collecting accurate cost data. Each base should develop APMM or similar program. The data collected from the programs should be centrally maintained and distributed to all installations to assist in conducting economic analysis.

6.2 Lack of ways to help field offices incorporate LCC concepts into facility process.

With the implementation of APMM to gather costs data, the proper tools must be provided to the field commands to incorporate life cycle cost concepts in facilities planning and acquisition. Methods to assist the field offices include: incentives for the

designer and inclusion of LCC concepts as a requirement in the contract documents prior to bidding.

6.2.1 Energy Performance Based Contracts

One way to ensure architect engineers (A/E) perform economic analysis is to require it in the A/E's design contracts. However, NAVFAC is restricted by law to pay the A/Es no more than 6% of the total project cost for facility designs.[FAR 15.903.(d)(1)(ii), 1997] If the cost to conduct life cycle costs analysis is not covered by the design fee, the A/E can be paid to conduct the analysis as a study. Project funds are allowed to cover this as a separate study. However, limited projects funds can eliminate that option.

If project funds are too tight to afford life cycle costs analysis, one way to see they are conducted is to provide an incentive to the A/Es who initially designs the projects. Energy performance based contracting is a new approach to provide incentives for designers to conduct life cycle cost analysis and reduce energy costs. The concept is a relatively simple one: a targeted energy performance level is established for a facility. If a facility's actual energy performance is better than the targeted energy performance the A/E receives a reward. If the facility falls short of the targeted energy performance, the A/E is penalized. If the facility meets the targeted performance there is no reward or penalty.

The energy performance based contract is being used in a project for the City of Oakland, CA. Oakland has awarded an $80 million firm fixed price contract to a design build (D/B) firm to design, engineer, construct, and commission a 420,000 sq. ft. office building. As part of the contract, the city and the D/B firm established the following energy performance criteria: Base Energy Performance (which the facility must obtain) - $487,000 in annual energy costs; Targeted Energy Performance - $450,000 annual energy costs (± $20,000); and Maximum Penalty/Reward - $250,000. If the facility actual annual energy consumption falls below $430,000, the D/B receives a reward (Maximum Reward $250,000); if the facility's annual energy cost is above $470,000, the D/B is penalized (Maximum penalty $250,000), see Figure 6.2.1[Eley, 1997].

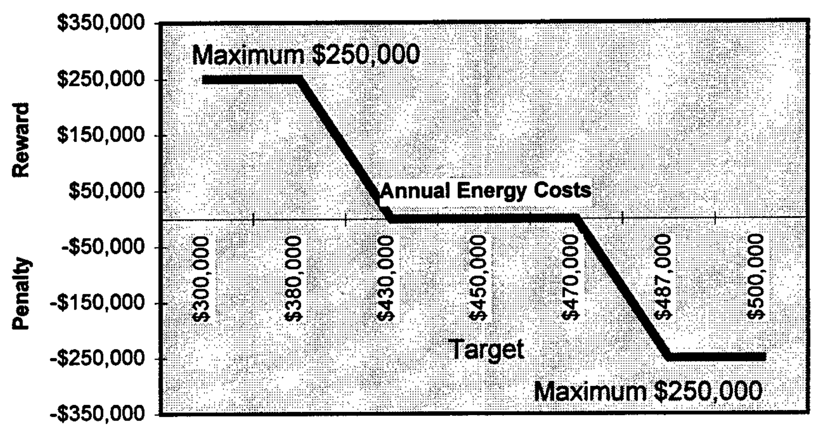

Figure 6.2.1 Energy Performance and Incentive [Taken from Eley, 1997]

The facility is under construction and completion is scheduled for the first quarter of 1998. The base and target energy performance levels were developed using a

computer simulation model (DOE-2 which was developed by the Department of Energy), federal guidelines and based on assumptions on how the building will be used and operated. The penalty and reward is based on a percentage of the facility's annual energy costs. Once the facility is constructed and in the second year of operation, a third party, which has been approved by the owner and the D/B, will monitor the facility energy consumption and develop a report. The findings of that report will determine whether the designer receives a reward or penalty.[Eley,1997]

Energy based performance contracts are an excellent incentive to make A/E design above and beyond the basic design criteria with no additional initial costs. However, before using an energy performance base contract, several issues need to be addressed. First, the contract should address only the energy uses the designer is responsible for such as, lighting, water heating, and space conditioning. Components that should be excluded are: building equipment, elevators, and mainframe computers. Second, if the facility is operated and managed significantly different from the original assumptions, then the targeted energy performance level should be reevaluated. Third, the designer should provide documentation showing that the facility's design, which has been selected to meet the targeted energy performance level, has the lowest life cycle costs. This will ensure other elements of the life cycle cost concept such as, maintenance considerations and the occupants comfort have not been sacrificed for lower annual energy costs. Finally, energy_performance base contracts supposedly can be used in conjunction with a variety of facility delivery systems, such as: separate contracts for A/E and construction contractor; separate contracts for A/E, mechanical designer, and

contractor; and contract for a design/build firm [Eley,1997]. In my opinion, energy performance based contracts should only be used on D/B contracts. Mainly for legal reasons, design build contracts holds accountability to one party.

Performance based contracts should not be limited to energy costs. An energy performance based contract is the first step. Once means are developed to accurately track the remaining facilities costs, such as maintenance and repair, performance based contracts can be expanded to incorporate these elements.

6.2.2 Life Cycle Cost Bidding

Another technique used to include life cycle cost concepts into facility projects is life cycle cost bidding. NAVFAC's Southern Engineering Field Division (SOUTHDIV) developed Life Cycle Cost Bidding, in lieu of lump sum initial cost bidding, as a means to procure facility or equipment projects which have significant energy and operation and maintenance costs. The primary purpose of life cycle cost bidding is to reduce the Navy's infrastructure cost by selecting the proposal with the lowest life cycle cost. It also saves the Navy money in design services. The contractor is performing the economic analysis rather than the Navy or an A/E firm.

SOUTHDIV policy on life cycle cost bidding is set forth in Southern Division Navy Facility Engineering Command Instruction 4330.71 [SOUTHNAVFACENGCOM INSTUCTION 4330.71], titled "Life Cycle Cost Bidding." According to the instruction, for life cycle cost bidding to be used in the procurement process the following four criteria must be met:

a. Facility or equipment must have significant operation (to include energy costs) and maintenance costs as compared to first costs.

b. There is a measurable way to bid the future cost of operation and maintenance.

"For example a test can be performed to verify the bidder's guaranteed maximum equipment energy consumption and/or a well defined scope for operations and maintenance is possible." [SOUTHNAVFACENGCOM INSTRUCTION 4330.71]

c. The facility or equipment must be a major portion of the scope of work.

"For example, it would not be desirable to bid a chilled water system on a life cycle costs basis if the package included a $10,000,000 building and only $500,000 for the chilled water system. If it were feasible to bid the chilled water system separately, life cycle cost bidding would be appropriate." [SOUTHNAVFACENGCOM INSTRUCTION 4330.71]

d. That the contractor performing the operation and maintenance on the facility or equipment will not displace or downgrade any present government workforce.[SOUTHNAVFACENGCOM INSTRUCTION 4330.71]

Once a project has been selected for the life cycle cost bid process, the solicitation package is developed. The solicitation package requires the contractor to provide an initial cost for the facility or equipment; complete a work sheet to determine the annual operating cost for the facility or equipment; and provide an annual maintenance cost (to cover a specified time period) for the facility or equipment. Once the bids are received, the initial, operating, and the maintenance costs for each bid is totaled. The project is

awarded to the contractor whose bid provides the lowest life cycle cost for the facility or equipment .

After the award and prior to the acceptance of the project, the contractor is to conduct a controlled test on the facility or equipment to ensure it meets the operating costs that were submitted in the bid. If the findings from the test show that the operating costs are higher than submitted in the bid, the contractor must repay the government for the excess costs. The amount to be paid to the government is addressed in the contracts documents. Normally, it is based on a calculation of the net present value of the annual overrun over the life of the of the facility or equipment [Fowler,1997]. For example, a chiller has been procured. The contractor as part of his bid submits an annual operating cost of $90,000/year. In accordance with the contract, the contractor conducts a controlled test (normally conducted in the factory before the unit is shipped). The results of the controlled test shows that the actual operating costs are going to be $100,000/year. The contractor must pay the government back for the $10,000 annual overrun for the life of the chiller. For a life of 25 years and a discount rate of 7%, the amount of the payment would be $116,540. In regards to maintenance cost, once the facility or equipment is accepted, the contractor is to provide maintenance service for the facility or equipment for a period of time set forth in the contract.[Fowler, 1997]

So far, SOUTHDIV has only used life cycle cost bidding on chiller projects. The main reason for chiller projects is that it is relatively easy to determine their operating costs. Facilities operating costs, on the other hand, are difficult to determine. This

should change with the use of the APMM program. Once operating costs can be accurately determined, life cycle cost bidding could be used on facility projects.

Until accurate operating costs are developed, a modified version of life cycle cost bidding could be used on facilities projects. The modified version would be awarded based on the sum of the initial and maintenance bids. The selected contractor would be held accountable for these two bid items. However, by contracting the building maintenance to a civilian contractor, federal workers' jobs are in jeopardy. In addition, operating costs might be compromised to obtain lower initial and maintenance costs.

Chapter 7.0 CONCLUSION AND RECOMMNEDATION

7.1 Conclusion

A major concern of the Navy is the amount of resources being consumed from owning, maintaining, and operating it's infrastructure. One way to reduce those cost is by effectively using economic analysis, based on life cycle cost concepts, in the decision making process throughout the facility process.

Economic analysis, based on life cycle cost concepts, focuses on all cost related to a project versus only initial cost. These costs include: initial, operating, maintenance, and disposal costs. There are four basic types of economic analysis: primary, secondary, investment, or design. The process of conducting an analysis is consistent regardless of type of analysis. To be an effective tool in the decision making process, economic analysis must be well documented and done in its entirety.

NAVFAC provides a variety of technical services in support of the Navy's infrastructure. NAVFAC is involved in all phases of the facility process including: planning, design, budgeting, construction and maintenance. As the facility experts for the Navy, NAVFAC must play a major role in implementing life cycle cost concepts.

The life cycle cost concept is not a new approach for the Navy. There have been a number of policies issued that incorporate the life cycle cost concept. The policies require that economic analysis, based on life cycle cost concept, be used as a tool to assist in determining which facility alternative best fulfills the Navy facility needs.

The findings from NAVFAC's "Mandating Life Cycle Consideration in Projects" report showed that despite the policies in place requiring utilization of life cycle cost concepts, the concepts are not being effectively applied. The report presented 18 issues that are hindering the use of this concept and presented six recommendations that will help with the implementation. Two important issues, from the NAVFAC report, were analyzed and recommendations made to help eliminate the obstacles.

The first issue was the lack of accurate cost data. Lack of accurate operation and maintenance cost data can greatly affect the result of an economic analysis. One way NAVFAC field offices are trying to track these cost is through the Activity Planning and Management Model, (APMM). The APMM is a facility management software program that tracks and stores facility related information. The program is being further developed to accurately track facility operation and maintenance costs. The cost data collected in the APMM will be used to perform better economic analysis on future facility projects.

The second issue was lack of ways for the field offices to incorporate life cycle cost concepts into the facility process. Field offices are under tight project budgets that cannot afford extra design costs. Two alternative ways to keep design costs down and still include life cycle cost concepts are: energy performance based contracts and life cycle cost bidding.

Energy based performance contracts provide incentives to A/Es to design a facility beyond the minimum energy requirements. By lowering the facility's energy consumption, the life cycle costs for the facility are reduced. Life cycle cost bidding

allows the field office to incorporate the life cycle cost concept in the solicitation process. Contractors submits life cycle costs for a facility or equipment in their proposals. This allows the Navy to select the proposal with the lowest life cycle cost and avoid the expense of performing economic analysis.

During the facility process, decisions need to incorporate life cycle cost concepts. It is NAVFAC responsibility to ensure these concepts are being implemented. Utilization of APMM, or a similar product, and providing the tools to implement the life cycle cost guidance at the field level as shown will greatly enhance NAVFAC's ability to reach their goal of reducing shore facility infrastructure costs.

7.2 Recommendations to properly oversee the implementation of Life Cycle Cost Concepts.

A Life Cycle Cost Board consisting of NAVFAC headquarters' and field office personnel should be established. The members should come from all the different areas of the facility process, to include: programming, funding, planning, design , construction, and public works. The board would be the sole point of contact for life cycle costs issues. Responsibility of the board would include:

(1) Conduct a detailed survey.

The first step is for the board to develop and issue a survey to all of NAVFAC offices involved in the facility process to determine:

(A) NAVFAC personnel's current knowledge of life cycle cost concepts

(B) All the current life cycle cost practices in use in the NAVFAC facility processes.

A survey with a similar theme is being developed by the Construction Industry Institute (CII). In 1995, CII assigned Research Team 122 to research the implementation of life cycle analysis in facility planning projects. One of the team's developments is a Life Cycle Analysis Self-Evaluation Tool (SET). The SET evaluates the knowledge of the interviewee in the area of life cycle cost concepts and measures the extent of implementation of life cycle cost analysis throughout the facility planning process. The SET is not due to be published until 1998. Accompanying the SET will be a scoring tool and an evaluation table to assist in assessing survey results. See Appendix C for a copy of SET. With a slight modification, the SET can be used to identify current practices and analysis tools being used by the NAVFAC community.

(2) Developing new life cycle cost policy and guidance.

Based on survey results, existing policies, and information from outside other agencies, a new life cycle cost policy and guidance should be developed. The first policies and guidance should be inwardly focused on NAVFAC. The guidance should be explicit and require economic analysis, based on life cycle cost, and be conducted in both the planning and design stage. The policy should also include prescribed methods and tools to be used in the economic analysis. Policies should then be outwardly focused. The policy developed for NAVFAC should be modified to address all parties involved in the facility process, to

include customers and the budget office. It should also require life cycle cost concepts in both the planning and the design phases of project developments. In issuing new policies, the board must coordinate life cycle cost policy with all other related policies. Related policies include: planning, value engineering, and sustainable design.

(3) Collect, maintain, update and distribute all information related to life cycle cost.

The board should be the central collection and distribution center of all life cycle cost information which include: policies, procedures, new approaches, and cost data. For example, APMM, Energy Performance Based Contracts and Life Cycle Bidding are new approaches that should be studied by NAVFAC and the conclusions from the study distributed to the field office. NAVFAC should also consider sponsoring pilot studies to help in the development of new approaches. For information to flow effectively, the board must establish open lines of communication between NAVFAC headquarters and the field offices.

(4) Develop training programs and implementation plans.

From the results of the survey, a new training program for life cycle costs concepts should be developed. The training program should include an implementation plan detailing requirements based on job description within the facility process.

(5) Coordinate efforts with other agencies and facility owners.

There are many other agencies working toward the same goal to reduce infrastructure operation and maintenance costs. Coordinate NAVFAC efforts with those of other agencies, such as: Department of Energy, General Service

Administration, Construction Industry Institute, and various Universities to reduce redundancy and improve the effectiveness of the individual efforts.

(6) Develop Corporate Metrics

Based on the results of the in-house survey develop corporate metrics to monitor success. The metrics are required to ensure that the implementation plan is working properly. Progress should be tracked using the same survey. Findings should be documented, tracked and published on a regular basis. Findings will also provide the raw data for further improvement of policies.

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Appendix A

Evaluation Approaches

This appendix presents the five approaches used to evaluate investment and design alternatives. The following examples are taken from "Life Cycle Costing for Design Professional" by Dr. Stephen J. Kirk and Alphonse J. Dell'isola.

A. Payback Period is the time, usually in years, required for the expected saving to equal the original investment. The time is used to judge the effectiveness of the investment alternative.

For the simple payback period, the time value of money is not used.

$$\text{Simple Payback} = \frac{\text{Initial Cost}}{\text{Annual savings}}$$

Example: New nursing tower (initial cost = \$20,000,000 to construct) is expected to reduce staffing cost (\$5,000,000 annually).

$$\text{Simple payback} = \frac{\$20{,}000{,}00}{\$5{,}000{,}000} = 4 \text{ years}$$

Discounted Payback is similar to the simple pay back except the time value of money is used. First, annual savings are converted to an equivalent present worth at the time of investment. Cumulate the equivalent present worth of savings until they equal the initial investment. The time required to make these two equal is the discounted payback period. The alternative with the shortest payback period, simple or discounted, is the best alternative.

Example : Using the same case as the simple payback, the cumulative equivalent present worth of the annual savings would be computed as shown below.

Cumulative discounted savings process (discount rate of 10%)

Year	**Present Worth (PW) Savings, $**	**Cumulative PW Savings, $**
1	$\frac{5,000,000}{(1.10)} = 4,545,000$	4,545,000
2	$\frac{5,000,000}{(1.10)^2} = 4,132,000$	8,677,000
3	$\frac{5,000,000}{(1.10)^3} = 3,757,000$	12,834,000
4	$\frac{5,000,000}{(1.10)^4} = 3,415,000$	15,849,000
5	$\frac{5,000,000}{(1.10)^5} = 3,105,000$	18,954,000
6	$\frac{5,000,000}{(1.10)^6} = 2,822,000$	21,776,000

Interpolating between the 5th and 6th year, the discount payback period would be approximately 5.3.

$$\frac{\$5,000,000}{(1.10)^{5.3}} = \$1,045,000$$

cumulating the annual savings to the 5.3 year yields a cumulative saving of $19,999,000.

B. Return on Investment is the most popular evaluation approach used in the private sector [Kirk & Dell'isola]. The expected savings due to an investment are expressed as a discounted percentage of investment.

Example: A new HVAC system (initial costs = $1,000,000) is expected to reduce annual energy cost (annual savings $150,000). First, the present worth annuity (PWA) is

calculated. A PWA of 6.667 as shown on the economic table is located between the discount rate of 8% and 10%. Through interpolation the return on investment is calculated to be 8.4%.

$$\text{PWA} = \frac{1{,}000{,}000}{150{,}000} = 6.667$$

C. <u>Saving to Investment Ratio</u>. The SIR is used to measure effectiveness of an investment. The SIR is calculated by dividing the present worth of the annual cost savings by the initial cost. If the SIR is higher than one, the investment can be considered cost-effective; the higher the ratio, the greater the dollar per dollar spent. The alternative with the highest SIR should be implemented.

Example: Installation of shelters on a loading dock is proposed to reduce heat loss at the northern facility. The estimated cost of one shelter alternative is \$15,000 and the estimated annual savings is \$4,200 for an 8 year period. For 8 years and a discount of 10%, the PWA factor is 5.335. Then the SIR is

$$\text{SIR} = \frac{\text{annual savings x PWA}}{\text{investment cost}}$$

$$= \frac{\$4{,}200 \text{ x } 5{,}335}{\$15{,}000}$$

$$= 1.494$$

The SIR in excess of 1 indicates that the investment is economically viable. However, the alternative with the highest SIR should be implemented.

D. For Design Analysis, the present worth method or the annualized method is used. The present worth method is used when the alternatives have the same economic and similar or no lead time. For the present worth analysis, all present and future cost are converted to a single point in time normally around the time of first expenditure. This is completed for all feasible alternatives. Once all the costs are in present value they are totaled. The alternative with the lowest cost is selected.

E. Annualized Method is used when alternatives have different economic lives. In the annualized method, all costs are converted to an equivalent uniform annual cost. The alternative with the lowest equivalent uniform annual cost is then selected.

Appendix B

Summary of "Mandating Life-Cycle Cost Considerations in Projects" Report

(Originally prepared by: Terrel Emmons, Associated Director for Design, NAVFAC Headquarters)

This Appendix is a condensed version of NAVFAC's original report " Mandating Life Cycle Cost Considerations in Projects".

Purpose/ Objective

The main goals/ purposes of the task force were to determine (1) What existing guidance and policy has been issued directing the use of life cycle cost concepts in the NAVFAC Community and is the various guidance adequate and compatible. (2) Determine the level of implementation of life cycle cost concepts in NAVFAC Facilities Programs. (3) Identify issues hindering the implementation of life cycle cost concepts, and, (4) Make recommendations for follow-on actions to improve the implementation of life cycle cost concepts.

Findings

Based on research of current DOD policy and guidance and interviews of NAVFAC Headquarters personnel and field office personnel, the following findings were made.

1. Current Policy requires LCC to be conducted in all Program Areas.
2. Also, the policy is generally consistent between the various instruction and manuals.
3. Personnel knowledge of current Life-Cycle Cost Policy is deficient at both NAVFAC Headquarters and Field Offices.
4. Documentation in the various stages of the Shore Facility Planning System (Facility Requirements Development, Engineering Evaluations, Planning Analysis, and Project Development), support the Life Cycle Cost Concepts.
5. Current Programming, Design, Construction, and Contracting practices are often inconsistent with Life Cycle Cost Policy requirements. One reason for the inconsistency is the "Lowest First Cost Mentality". NAVFAC personnel are under tight project budget constraints. The tight budgets do not permit increases in facility projects first costs, thus "Lowest First Cost Mentality".
6. Issues hindering the implementation of Life Cycle Cost Concept:
    6.1. Lack of specific guidance from the Office of Secretary of Defense and Navy Comptroller.
    6.2. NAVFAC's customers do not understand the life cycle cost concept.
    6.3. There are no recognized standards for assessing certain material and products life cycle costs.
    6.4. Lack of accurate costs data in some areas

6.5. Preliminary estimates of facility cost are based on unit cost (For example, 1000sq ft of office space cost s $100/sq.ft (unit cost), so the office space should cost $100,000). The current guidance for unit cost is set too low, which causes the facility's preliminary estimate to be low. The preliminary estimate is used to establish project budget. Low facility project budgets limits the use of life cycle cost analysis.

6.6. Too much emphasis on new construction instead of renovation and reuse of existing facilities.

6.7. Hesitancy to use new types of materials

6.8. Limited use of recycled materials due to lack of testing data, industry standards, and lack of knowledge of their costs and uses

6.9. Limited proof that Life Cycle Cost Concepts are valid.

6.10. Program Budgets for facility projects are decreasing. But, rather than dropping projects, customers would rather cut the budget on each project. Which limits or nullifies the use of life cycle cost approaches.

6.11. NAVFAC personnel are inexperience in pursuing life cycle cost concept through their A/Es.

6.12. Personnel in the field lack training in the use life cycle cost concepts when making design decisions.

6.13. Insufficient time allotted for designing projects restricts the use of life cycle cost concepts.

6.14. Unreliable data on existing facilities utilities consumption. Therefore project personnel are unable to determine if existing facilities are performing up to energy standards or should do they need to be upgraded or replaced.

6.15. Insufficient data for projecting facilities components life expectancy.

6.16. Life cycle cost analysis tools are inadequate.

6.17. A/E have no incentives to go above and beyond the basic design.

6.18. Not quantifying life cycle cost benefits in terms of increased productivity from properly designed and maintained workspaces.

7. Conflicts between Life Cycle Cost Policy and Value Engineering (VE) Policy. FAR requires VE changes to have an instant savings. If a VE change has a life cycle cost savings, the government must receive an instant savings.

8. Sister Services (Air Force and Army) are experiencing generally the same problems.

8.1. No link between construction budget and operation and maintenance budget.

8.2. Budgets are locked in prior to the start of design.

8.3. Navy and Army Comptroller view the unit costs used to develop facility budgets as a ceiling and not as averages.

8.4. Lack of operation and maintenance funds to properly service a facility makes decision makers favor new construction rather than viewing each alternative equally.

8.5. Preventive Maintenance (PM) Programs are inadequate. Improved PM programs can reduce the costs of operation and maintenance on the older facilities.

9. Current analysis tools do not consider all pertinent costs (i.e. increased productivity from better design interiors, costs related to sustainable design).

Recommendations

As clearly stated in the Findings, there is adequate DOD policy mandating the use of life cycle cost concepts; however, for various reasons the life cycle cost policy is not being implemented properly. Therefore, NAVFAC should develop an implementation plan to ensure life cycle cost concept are effectively used. For that purpose the following recommendations are provide:

1. Establish a single point of contact within NAVFAC Headquarters Planning Department to handle all Life Cycle Cost Issues.

2. Review all Programming, Planning, and Design Practices in NAVFAC Headquarters and Field Offices to determine the various life cycle cost concepts employed.

3. Develop and issue one new Life Cycle Cost Policy that relates all other policy and guidance.

4. Establish a training program to educate all of NAVFAC on the life cycle cost concepts and analysis tools.
5. Review, evaluate, and if necessary revised Life Cycle Cost, Value Engineering, and Sustainable Design Policy to ensure they are consistent with one another and current with today's practices (improved methods)
6. Establish metrics to monitor progress.

Appendix C

SELF EVALUATION - LIFE CYCLE COST ANALYSIS

Construction Industry Institute

<u>Note: This is a CII draft product as of July 1997.</u>
<u>It has not been approved for release or use.</u>

Most organizations when asked about *life cycle cost analysis* (LCCA) indicate that it is done routinely. This questionnaire is intended to assist management in determining the extent of the use of LCCA in their organization.

(Place an "x" in the appropriate response boxes i.e. ☐)

A. What is your organizations role in the project? (check all that apply)

☐ *Owner* ☐ *Designer/Engineer*
☐ *Constructor*

B. This survey is being completed for: (check One)

☐ *General Information* ☐ *Specific Project*

C. Which overriding issues are considered in the project analysis?
(Check all that apply)

☐ *Political* ☐ *Regulatory*
☐ *Budget* ☐ *Security*
☐ *None* ☐ *Other* ____________

1. Which measures are used to prioritize and select the "best" projects for implementation?

☐ *Return on Investment* ☐ *Net Present Value*
☐ *Simple Payback* ☐ *Savings/Investment Ratio*
☐ *Other* ______________

2. What method is used to determine the evaluation of alternatives?

☐ *Return on Investment*
☐ *Simple Payback*
☐ *Other* ______________
☐ *Net Present Value*
☐ *Savings/Investment Ratio*

3. LCCA is used for the following:
(Check all that apply)

☐ *Risk Assessment*
☐ *Operations/Maintenance*
☐ *Project Prioritization*
☐ *Construction*
☐ *Project Planning*
☐ *Energy Conservation*
☐ *Design*

4. At which levels is LCCA used? (Check all that apply)

☐ *Project Scoping/Evaluation*
☐ *Project Standards/Guidelines*
☐ *Preliminary Design*
☐ *Equipment/Material Selection*
☐ *Detailed Engineering/Design*

5. Who else is required to use LCCA? (Check all that apply)

☐ *Engineering Design Contractor*
☐ *Key Vendors*
☐ *Construction Contractor*
☐ *Sub-Contractors*
☐ *Suppliers*

6. Who is required to implement LCCA? (Check all that apply)

☐ *Project Developers*
☐ *Design Engineers*
☐ *Project Managers*
☐ *Project Engineers/Engineering Groups*
☐ *None*

7. What major LCCA cost categories are considered during project planning?
(Check all that apply)

☐ *Initial*
☐ *Maintenance*
☐ *Operating*
☐ *Decommission/Recommission*

8. What method is used for fiscal justification of projects?

- ☐ *Return on Investment*
- ☐ *Net Present Value*
- ☐ *Simple Payback*
- ☐ *Savings/Investment Ratio*

9. At what stage is life cycle cost considered? (Check all that apply)

- ☐ *Planning*
- ☐ *Preliminary Design*
- ☐ *Final Design*
- ☐ *Construction*

10. Are the project specific parameters (i.e. standards, scope, specifications, etc.) influenced by life cycle decisions?

- ☐ *Yes*
- ☐ *No*

11. When are the project parameters communicated to the project team?

- ☐ *During Planning*
- ☐ *During Design*
- ☐ *During Construction*
- ☐ *Instantly*

12. Which project parameters are consistent with life cycle decisions for a given project? (Check all that apply)

- ☐ *Scope of Project*
- ☐ *Criteria*
- ☐ *Standards*
- ☐ *Specifications*

13. Has a life cycle cost management system been established to maintain O&M data and design decisions in a form that supports operations and maintenance management and feedback of O&M experience to future facility designs?

- ☐ *Yes*
- ☐ *No (Go to 15)*

14. Which elements of the cost management system are established? (Check all that apply)

- ☐ *Operation &Maintenance Cost Database*
- ☐ *Lessons Learned Feedback*
- ☐ *Criteria Revisions*
- ☐ *Post Occupancy Evaluation*

15. Are post-construction audits of life cycle decisions performed to determine if those decisions yielded the anticipated results?

☐ *Yes* ☐ *No*

16. Is life cycle implementation adequately supported with staff and funds?

☐ *Yes* ☐ *No*

17. Do programs exist to assure that life-cycle cost management principles are communicated and applied?

☐ *Yes* ☐ *No (Go to 19)*

18. Check all of the programs that apply.

☐ *On the Job Training* ☐ *Workshops*
☐ *Basic LCC Training* ☐ *Meetings/Conferences*
☐ *Exchange of Staff* ☐ *Other* ____________

19. Is there formal recognition that control of life-cycle cost is an essential and effective element of the mission of the organization?

☐ *Yes* ☐ *No (Go to 21a. to 21b.)*

20. Check all of the items that apply.

☐ *Performance Standard* ☐ *Special Awards*
☐ *Mission/Policy Statement* ☐ *Staff Meeting Subject*
☐ *Other* ________________

21a. **(Owner)** How does your organization communicate to Designer/Engineer or Constructor to use Life Cycle Analysis?

☐ *Checklist Item* ☐ *Criteria/Standards*
☐ *Scope of Project* ☐ *Project Contract*
☐ *Other* ________________ ☐ *No Formal Communication*

21b. **(Designer-Constructor)** How does your organization communicate to your designers to use Life Cycle Analysis?

☐ *Checklist Item* ☐ *Criteria/Standards*

- ☐ *Scope of Project*
- ☐ *Other* ________________

22. Does your organization assure that contract incentives demonstrate savings in expected life-cycle cost rather than initial cost only?

    ☐ *Yes* ☐ *No (Go to 24a. or 24b.)*

23. Which programs does your organization use?

    - ☐ *Value Engineering Clause*
    - ☐ *Solicitation for bids*
    - ☐ *Other*
    - ☐ *Other Contract Clauses*
    - ☐ *Contract Negotiations*

24a. **(Owner)** Does your organization direct Designer/Engineers and constructors to document clearly their design decisions made to control life cycle cost and the subsequently expected operating consequences for each project?

    ☐ *Yes* ☐ *No (Go to 26)*

24b. **(Designer-Constructor)** Does your organization direct designers to document clearly their design decisions made to control life cycle cost and the subsequently expected operating consequences for each project?

    ☐ *Yes* ☐ *No (Go to 26)*

25. To what extent does your organization check these decisions?

    - ☐ *Not at all*
    - ☐ *Formal audit*
    - ☐ *Checklist (Informal Review)*

26. To what extent does senior management reinforce life cycle cost analysis? (Check all that apply)

    - ☐ *Not at all*
    - ☐ *Formal audit*
    - ☐ *Checklist (Informal Review)*

27. Identify important components which include life-cycle evaluation. (Check all that apply)

- ☐ *Mechanical Systems*
- ☐ *Structural Systems*
- ☐ *Utilities*
- ☐ *Other* ________________
- ☐ *Electrical Systems*
- ☐ *Architectural Components*
- ☐ *Process*

28. Life-cycle evaluation is included in which of the following decision processes. (Check all that apply)

- ☐ *All Projects*
- ☐ *Repair/Replace systems*
- ☐ *Major Rehabilitation Projects*
- ☐ *Grass Roots Projects*
- ☐ *New Technology Applications*

29. What are the most relevant factors considered in the life-cycle cost evaluation of alternatives?

- ☐ *Initial Costs*
- ☐ *Maintenance Costs*
- ☐ *Other* ________________
- ☐ *Operation Costs*
- ☐ *Useful Life*
- ☐ *Decommission/Recommission Costs*

30. Is life-cycle cost analysis included in:

a. Company statements on values, strategies, and policies?

- ☐ *Yes*
- ☐ *No*

b. Performance evaluation standards of senior and project management.

- ☐ *Yes*
- ☐ *No*